AN EVENT-RELATED POTENTIAL EVALUATION OF THE COGNITIVE PERFORMANCE OF U.S. NAVY ALCOHOLICS

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Report No. 90-38

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Report No. 90-38, supported by the Naval Medical Research and Development Command, Department of the Navy, under research Work Unit 62233N- NM33P30.005-6003. The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U. S. Government.

SUMMARY

Event-related potential (ERP) component parameters were used as dependent measures in an evaluation of the functional aspects of cognition in alcoholics. Previous ERP studies indicate that alcoholic subjects differ from nonalcoholics in unique ways in their brain electrical response to stimuli, and that these differences may aid in the identification of alcoholic group membership.

Two groups (11 alcoholics and 11 nonalcoholics) of age- and education-matched volunteer subjects were used. The alcoholics group who were diagnosed according to DSM-III-R criteria consisted of U. S. Navy and Marine Corps enlisted men. The nonalcoholic group was composed of 10 males and 1 female. None of the subjects were taking medication, and none were classified as poly-drug abusers. All subjects were screened for current drug use.

All subjects completed 300 artifact-free trials of a binaural auditory "oddball" task. The WAIS-R was administered as an additional measure of cognitive functioning.

Three ERP components significantly differed between groups. There was a group main effect for P50 and N1-P2 amplitude, a group by stimuli interaction for P50 latency and P300 amplitude. A group main effect for the verbal WAIS-R subtest scores was also found and many of the scores were significantly correlated with ERP parameters. The results of this study support the idea that alcoholism has a deleterious effect on the ERPs of human subjects. The reduced amplitude for N1-P2, P300 and the lack of an "oddball" effect replicate the results of other ERP studies with alcoholics.

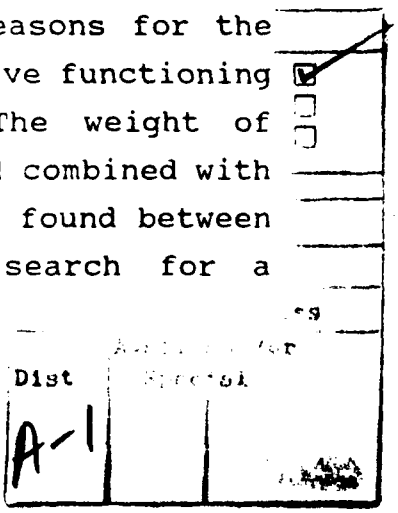
A stepwise discriminant analysis (SWDA) was done using the ERP component amplitude and latency values. The results showed that 100 percent of the training set subjects were correctly classified. The equation derived from the training set classification coefficients correctly classified six alcoholics in an different sample of six. The present results suggests that the identification of alcoholic group membership may be feasible from electrophysiological data alone.

INTRODUCTION

Numerous studies have documented a difference in brain electrical activity between alcoholics and controls (e. g., Begleiter, Porjesz, & Chou, 1981; Ehlers & Schuckit, 1990; Hill, Steinhauer, Zubin, & Baughman, 1988; Patterson et al., 1989; Porjesz & Begleiter, 1983; Skerchock & Cohen, 1984; Spitzer & Newman, 1987). These studies have demonstrated that the neurophysiologically measured (e.g., computerized tomography scans [CT], electroencephalography [EEG]) cognitive activity of alcoholics varies significantly from that of normal nonalcoholics. Testing with neuropsychological instruments (e.g., Wechsler Adult Intelligence Scale [WAIS], Raven Progressive Matrices) has also shown that alcoholics are cognitively dysfunctional (Goodwin & Hill, 1975; Jones & Parsons, 1972; Parsons & Leber, 1982; Patterson, Williams, McLean, Smith, & Schaffer, 1987; Ryan & Butters, 1983).

The genetic transmission of the vulnerability for alcoholism has been well documented in a series of family, twin, adoption, and blood marker studies (Cadoret, Cain, & Grove, 1980; Cotton, 1979; Goodwin, 1985; Goodwin et al., 1974; Hill, Goodwin, Cadoret, Osterland, & Doner, 1975; Hill, Aston, & Rabin, 1988; Schuckit, 1985). It appears that alcoholism can be attributed to an interaction between genetic and environmental factors. This interaction has been described in terms of a multifactorial model (Cloniger, Bohman, Sigvardsson, & Von Knorring, 1984; Hill et al., 1988; Schuckit, 1985). In this model, individuals who are genetically predisposed to the development of alcoholism are impacted by various environmental factors, and subsequently exhibit clinical signs of alcoholism.

A genetic factor is often cited among the reasons for the differences in brain electrical activity and cognitive functioning between alcoholics and normal nonalcoholics. The weight of evidence that alcoholism is genetically transmitted combined with the electrophysiological differences that have been found between alcoholics and nonalcoholics have led to the search for a



biological marker for alcoholism. In some studies when children of nonalcoholics (family history negative, FH-) have been compared with children of alcoholics (family history positive, FH+) they have revealed a significant difference in cognitive functioning and electrophysiological activity (Begleiter, Porjesz, Bihari, & Kissin, 1984; Drejer, Theilgaard, Teasdale, Schulsinger, & Goodwin, 1985; Gabrielli et al., 1982; Hill et al., 1988; Pollock et al., 1983). Various strategies have been used to gather electrophysiological evidence in support of the genetic transmission of vulnerability to alcoholism. Some investigators have found that EEG alpha and beta activity and event-related potentials (ERPs) are altered in subjects whose family history is positive for alcoholism (Begleiter et al., 1984; Ehlers & Schuckit, 1990; Elmasian, Neville, Woods, Schuckit, & Bloom, 1982; Gabrielli et al., 1982; Steinhauer, Hill, & Zubin, 1987). Other investigators have found no differences between FH- and FH+ subjects (Polich & Bloom, 1988; Whipple & Noble, 1986).

Most electrophysiological studies of alcoholics have investigated a positive component that occurs at approximately 300 milliseconds (ms) poststimulus (P300). ERP studies that have compared alcoholics and nonalcoholics have found significantly smaller P300 amplitudes and longer P300 latency differences in alcoholics (Patterson et al., 1987; Pfefferbaum, Horvath, Roth, Clifford, & Kopell, 1980; Porjesz & Begleiter, 1985; Porjesz, Begleiter, & Sammuelly, 1982; Skerchock & Cohen, 1984). Typically the experimenters used "chronic" alcoholics with a mean age of approximately 36 years and who had used alcohol in excessive quantities for at least seven continuous years (Ellis & Oscar-Berman, 1989).

Alcoholism definitely produces cognitive impairment (Grant, 1987). Although alcoholics treated by the Navy are given formal treatment and abstain from alcohol, no cognitive testing is done to ensure that they are fit to return to duty. Porjesz and Begleiter (1985) have provided a review of their studies that demonstrate attenuated P300s in alcoholics after two to five years of

abstinence. However, it should be mentioned that Porjesz and Begleiter used older chronic alcoholics, with a mean age of 37 years as subjects. Therefore it seems reasonable to suggest that the chronic alcoholics in the Porjesz and Begleiter studies may have sustained brain damage due to their heavy, long-term use of alcohol. Although their work suggests that the P300 continues to be attenuated in abstinent alcoholics, a longitudinal study has not been conducted. P300 has been related to cognitive performance and if an electrophysiological rebound, postrehabilitation, does exist it may provide a measure of fitness for duty.

Shagass, Ornitz, Sutton, and Tueting (1978) have suggested that two major goals of ERP research in psychopathology should include the development of "objective diagnostic indicators". Presently, objective and subjective reports of behavioral change and the physical absence of alcohol and alcohol by-products in blood and urine are most often used as the criteria for recovery from substance abuse. These criteria have the following weaknesses: (a) an inability to diagnose until a critical incident occurs, (b) an inability to test the efficacy of neuronal pathways, and (c) an inability to document the functional recovery of the substance abuser. A few studies have been conducted that indicate that ERP component parameters may be of value in the diagnosis and prediction of alcoholism (Hillyard, 1978; Patterson et al., 1978; Porjesz & Begleiter, 1979; Sandman, Gerner, O'Halloran, & Isenhart, 1987). Two such related components are the N1-P2 component, which appears to differentiate between attended and unattended channels, and the N100 component, which seems to be a gauge of stimulus relevance (Hillyard, 1978). For example, in bimodal tasks using visual and auditory stimuli, the N1-P2 component is larger to attended stimuli within the designated channel modality. In addition, the N100 for the target stimuli was also pronounced. Porjesz and Begleiter (1979) found that a group of alcoholic subjects did not display a N1-P2 amplitude difference between relevant and irrelevant stimuli. Patterson et al. (1987) found that N100 amplitude was smaller for alcoholics. They interpreted

their results to mean that "sensory filtering" processes are dysfunctional in alcoholics. Such a deficit could have a significant impact upon the operational performance of military personnel. Sonarmen, for example, are tasked with concurrently monitoring visual and auditory equipment to discriminate relevant from irrelevant signals. Finally, Sandman et al. (1987) found that the N1 and P2 components were smaller in alcoholic subjects. Sandman et al. correctly classified nine of 16 alcoholic subjects or sixty percent (twenty five percent was chance) by means of a stepwise discriminant analysis function (SWDA).

The first pronounced wave in the auditory cortical evoked potential is the P50. The P50 has been used as a measure of the strength of sensory gating, and sensory gating appears to be a mechanism of selective attention. The P50 may be a better gauge of sensory gating than later components because it is relatively unaffected by changes in the subject's level of interest or different sound intensities (Hillyard, Hink, Schwent, & Picton, 1973; Pfefferbaum, Horvath, Roth, Tinklenberg, & Kopell, 1980). Although P50 has not been investigated in alcoholics, Adler et al. (1982) and Franks, Adler, Waldo, Alpert, & Freedman (1983) have used P50 as a measure of sensory gating in certain psychopathological states in which attentional processes are deficient. They have demonstrated that schizophrenics and manics are unable to gate or suppress repeated paired-stimuli presentations. The measurement of P50 in a paired-stimuli paradigm probably provides a better measure of basic attentional capabilities because it does not require conscious task attention, is unaffected by sound intensities, and is not task oriented.

Overall, it appears that previous research serves as evidence for the sensitivity of the ERP as a tool for measuring various aspects of cognitive performance. Using ERP component parameters as a dependent measure enables the functional aspects of cognition (filtering, discrimination, memory encoding, memory retrieval, and decision making) to become manifest (Donchin, Kramer, & Wickens, 1986). Job performance is highly correlated with the ability to

perform these covert behaviors. Thus far, the ERP evidence gathered to date indicates that alcoholic subjects differ in unique ways in their brain electrical response to stimuli, and that these differences may aid in the diagnosis and prediction of group membership for alcoholics. Therefore, the ERP seems to be a promising chronometric measure for the prediction of alcoholic group membership, the diagnosis of dysfunctional neuronal pathways, and the evaluation of treatment progress.

The long-term negative effect of alcoholism on the physical and psychological health of the general population has been extensively documented (Liska, 1988; Steele & Josephs, 1990; Tarter & Ryan, 1983). Yet, additional studies have been conducted that have used exclusively military personnel. Durning and Jansen (1976) have reported a large proportion of problem drinkers among Navy recruits (forty six percent, n = 2045), and Kolb and Gunderson (1983), after a review of medical records, found that problem drinkers require more hospital care during their first twelve years of service (alcoholics spent 75.1 days in the hospital for all reasons compared with 14.5 for controls). If ERPs could accurately discriminate alcohol abusers early in their careers, there would be a demonstrable savings in health care and the avoidance of debilitating diseases (Kolb & Gunderson, 1981). Because the Navy is becoming a more selective armed force, there is a need to be able to accurately predict an individual's present or potential substance abuse status. Also, since the Navy's treatment goal is to return personnel to their jobs, the Navy has a need to know if the personnel remain cognitively qualified to optimally perform their jobs.

METHOD

Subjects

Two groups (11 alcoholics and 11 nonalcoholics) of age- and education-matched volunteer subjects were recruited. The alcoholics were all awaiting treatment at the Navy Alcohol Rehabilitation Center at NAS Miramar, California. They were

diagnosed according to DSM-III-R criteria and consisted of U. S. Navy enlisted men with a mean age of 25.1 years (SD = 4.0) and a mean education level of 12.73 years (SD = 1.86). They had been abstinent for at least three weeks. All of the alcoholic subjects were free of liver disease, were not taking medication, had been screened for current drug use, and did not have a history of head trauma or seizures. None of the alcoholic subjects were classified as poly-drug abusers. Eight of the alcoholic subjects had a family history positive (FH+) for alcoholism and three subjects had a family history negative (FH-) for alcoholism. Family history information was gathered through self-reports and a subject was considered FH+ if a parent was reported as alcoholic.

The nonalcoholic comparison group consisted of healthy individuals who did not have a history of alcohol or drug abuse. The group was composed of 10 males and one female and had a mean age of 27.9 (SD = 4.8) and a mean education level of 13.45 (SD = 2.42). Polich, Burns, and Bloom (1988) found no significant differences have been found between male and female alcoholics and nonalcoholics using an auditory ERP paradigm. None of our nonalcoholic subjects were taking medication or had a history of head trauma. Six nonalcoholic subjects reported a FH+ history for alcoholism and five reported a FH- history for alcoholism.

Procedure

All subjects completed 300 artifact-free trials of a 20/80 auditory "oddball" task and the Wechsler Adult Intelligence Scale (WAIS-R). During the oddball task, the subjects were seated in a quiet room and were instructed to focus on a fixation cross placed on the wall, about 135 cm from the subject's head, directly in the subject's line of sight. A 1500 Hz tone, with a 2 ms ramp and a 24 ms duration, was randomly intermixed and presented on 20 percent of the trials (rare tone). A 750 Hz tone, with a 2 ms ramp and a 22 ms duration, was randomly intermixed and presented on 80 percent of the trials (frequent tone). All tones were delivered binaurally at 70 nHL with a constant 50 NHL white background noise. The interstimulus interval varied randomly between 900 and 1400 ms.

The subjects were instructed to avoid excessive eye blinks and body and eye movements. They were told to remember the number of high tones that occurred and to ignore the low tones. Each subject was given approximately 10 high and 40 low-tone practice trials to verify their understanding of the task. All subjects scored above the minimal criterion of 80 percent in the practice session.

The task lasted approximately 10 minutes. The subjects were then given a 15 minute rest period after which the WAIS-R was administered. The total testing time was about 90 minutes.

Equipment

ERPs were amplified (x 20,000), filtered (bandwidth 1-30 Hz), averaged, and stored on a Nicolet Compact Four Electrodiagnostic System (C-4). ERPs were sampled for 100 ms prestimulus (baseline) and for 800 ms poststimulus (250 Hz sampling rate). Stimuli were delivered binaurally via a Telephonics headset (TDH-39p).

Electrodes

Grass gold cup electrodes were attached at Fz, Cz, and Pz in accordance with the 10-20 International system. All electrodes were also attached with paste. Beckman biopotential electrodes were attached supra to the left and right eyes to serve as ground and to monitor eye movement, respectively. Trials with a signal greater than 100 microvolts were automatically rejected. Gold cup electrodes were attached to the mastoids, linked, and used as reference. All impedances were kept below 5 kohm.

Analysis

The component amplitude and latency values were extracted from the Nicolet C-4 and transferred to a VAX mainframe computer for analysis. Table 1 shows the latency window used for each component. Components were defined as the maximum amplitude values (in the required direction; P = positive; N = negative) located within the established time windows. The N1-P2 and N2-P3 values were determined by subtracting the negative from the positive component values. Porjesz, Begleiter, and Sammuelly (1982) found significantly smaller N2-P3 amplitudes in a group of alcoholics.

Table 1

Component Latency Windows

Component	Latency
P50	20 - 100 ms
N100	50 - 150 ms
P200	150 - 250 ms
N200	150 - 400 ms
P300	250 - 500 ms

The component amplitude and latency values were subjected to repeated measures, three-way (Group x Site x Stimuli) multiple analysis of variance (MANOVA). Post-hoc MANOVAs, one-way analysis of variance and t-tests were conducted wherever appropriate. The ERP component values were analyzed by multiple discriminant analysis (SPSS-X User's Guide, 1988). Discriminant analysis was used because the various component values are intercorrelated. The coefficient functions gained from the analysis may be used to evaluate the strength of interdependence among the measures. This procedure may identify ERP components that are useful in distinguishing group membership (Barr, 1984).

RESULTS

Age and education, in number of years, were subjected to separate one-way analysis of variances and showed no significant difference between the groups. Table 2 displays the performance and related group mean data. From an inspection of the group means, it appeared that significant differences may exist between the groups, especially for the number of trials rejected. The number of trials rejected may have an effect on the averaged ERP. If excessive trials are rejected, it may be assumed that muscle

activity is at fault and that it may be present to a lesser degree even for the accepted trials. Also, excessive rejected trials result in a longer session time and may indicate long intervals between accepted trials which may confound the results. Therefore, separate two-way MANOVAs (Tones x Group) were done and revealed no significant differences between the groups for the number of rare and frequent tones rejected and not rejected. The performance score was subjected to a one-way analysis of variance and no significant differences between the groups were found.

Table 2

Group Means for Rare and Frequent Tones Accepted and Rejected and Group Performance Scores.

Tone	Status	Group			
		Alcoholic		Nonalcoholic	
		M	SD	M	SD
Rare	Accepted	57.54	(8.36)	59.73	(6.51)
Rare	Rejected	24.64	(22.63)	15.64	(11.69)
Frequent	Accepted	215.45	(42.66)	234.73	(14.40)
Frequent	Rejected	115.45	(116.01)	54.27	(40.86)
Rare	Remembered	85.45	(32.83)	77.36	(13.48)
Performance Score		.95	(.08)	.99	(.01)

Note: The performance score was computed by dividing the number of rare tones remembered (RR) by the number presented (RP), unless RR was larger than RP. If RR was larger, then the difference between RP and RR was subtracted from RP and then divided by RP.

Figure 1 shows the grand means for each group, site, and stimuli. Here it can be seen that the mean P300 value for both groups is largest for the rare tones and smallest for the frequent tones.

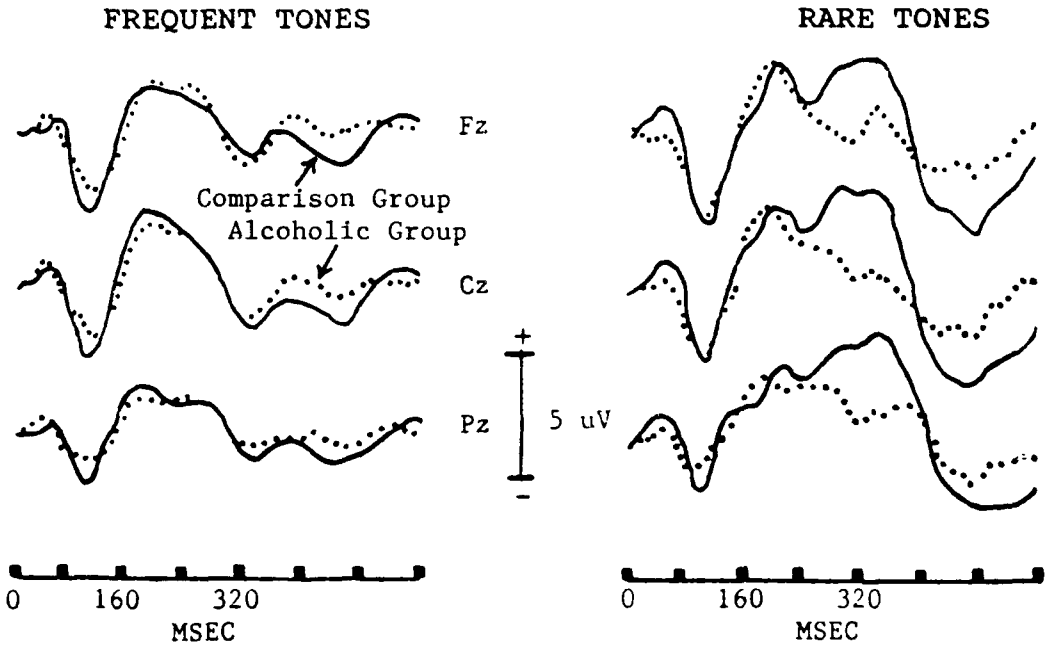


Figure 1. Grand averaged ERPs for both groups, rare and frequent tones, Fz, Cz, and Pz electrode sites.

P50 Component

MANOVA results indicated that there was a main effect for group for P50 amplitude ($F(1,20)=4.48$, $p<.05$). The nonalcoholic group had significantly greater P50 amplitude regardless of stimuli or site. There was a significant group by stimuli interaction ($F(1,20)=4.71$, $p<.05$) for P50 latency. The alcoholic group demonstrated longer latencies to rare tones while the nonalcoholic group had longer latencies to frequent tones. Table 3 shows the P50 mean amplitudes and latencies, averaged across sites.

Table 3.

Mean P50 Amplitudes and Latencies

	Alcoholics		Nonalcoholics	
	M	SD	M	SD
Amplitude				
Rare Tones	.45	1.68	1.89	1.36
Frequent Tones	.51	1.01	.92	1.00
Latency				
Rare Tones	53.03	17.08	41.97	10.44
Frequent Tones	43.18	10.45	46.79	11.07

N100 Component

No significant group effect or group interactions were found for N100 amplitude. There was a significant main effect for site ($F(2,40)=20.81$, $p<.01$) and an inspection of the mean population by site amplitude values suggests that the N100 was largest frontally and smallest parietally, which has been found in other reports (Naatanen & Picton, 1987).

P200 Component

There were no significant group main effects or group interactions for P200 amplitude or latency. A significant site effect was found ($F(2,40)=4.82$, $p<.01$), P200 amplitude was largest at site Cz.

N1-P2 Component

The analysis of the N1-P2 component amplitude revealed a significant group effect ($F(1,20)=4.31$, $p=.05$). An inspection of the group means indicates that, overall, the alcoholic group had smaller N1-P2 amplitudes. The mean N1-P2 amplitude for the alcoholic group was -3.14 ($SD=0.69$) and for the nonalcoholic group it was -4.28 ($SD=1.69$). A significant site effect ($F(2,40)=5.40$, $p<.01$) and a significant stimuli effect ($F(1,20)=8.83$, $p<.01$) were found. The N1-P2 amplitudes were largest frontally and smallest parietally, and the rare tone amplitude was larger than the

frequent tone amplitude.

N200 Component

A group by stimulus interaction was found that approached significance ($F(1,20)=3.86$, $p<.06$). The amplitude results also showed a significant site effect ($F(2,40)=7.28$, $p<.01$) and stimulus effect ($F(1,20)=4.42$, $p<.05$). The site and stimulus means indicate that amplitudes were largest frontally and smallest at the central site, and that the rare tones had the largest amplitudes. A significant stimulus effect ($F(1,20)=26.34$, $p<.01$) was found for N200 latency. The overall mean latency values showed that the frequent tones had longer latencies.

P300 Component

A significant group by stimulus interaction ($F(1,20)=9.17$, $p<.01$) was found for the P300 amplitude. MANOVAs were conducted on the P300 amplitudes between the groups for the rare and frequent tones. The results showed that the rare tones differed significantly ($F(1,20)=7.65$, $p<.01$), but that the frequent tones did not. Separate within-group MANOVAs revealed no significant difference between rare and frequent tones for the alcoholic group. The nonalcoholic group, however, showed a significant difference ($F(1,10)=36.99$, $p<.01$) between rare and frequent tones, with the rare tone being larger. The across site mean rare and frequent tone amplitude for the alcoholic group was 2.63 ($SD=1.63$) and 1.37 ($SD=1.05$), respectively. The across site mean rare and frequent tone amplitude for the nonalcoholic group was 4.64 ($SD=1.43$) and 0.38 (1.57), respectively.

Although there were no significant group main effects or interactions for P300 latency, the alcoholic group had longer mean latencies at all sites and for both stimuli with little between-group variability. There was a main effect for stimuli ($F(1,20)=12.68$, $p<.01$). An examination of the means indicates that, overall, the latencies of the frequent tones were longer than those of the rare tones.

N2-P3 Component

Porjesz, Begleiter, and Sammuelly (1982) reported that the N2-P3 for alcoholics was significantly smaller, therefore the N2-P3 was compared between groups. No group main effects or interactions were found for the N2-P3 component amplitude. There was a significant stimulus effect ($F(1,20)=24.53$, $p<.01$). The means indicate that the rare tones had larger amplitudes than the frequent tones.

WAIS-R

The verbal and performance WAIS-R subtest scaled scores were subjected to separate two-way (group x subtest) MANOVAs. A group main effect was found for the verbal subtests ($F(1,20)=6.09$, $p<.05$), but no interaction was found. No group main effect or interaction was found for the performance subtests. The mean verbal IQ for the alcoholic group was 101.3 (SD = 7.8) and for the comparison group it was 109.3 (SD = 8.3). Both mean scores are within a standard deviation (15.0) of the group norm of 100 for the WAIS-R.

Discriminant Analysis

All of the component amplitude and latency values were entered into a SWDA to determine which variables would provide the optimum separation of the groups. The results showed that 100 percent of the training set subjects (50 percent is chance) were correctly classified. The equation derived from the training set classification coefficients correctly classified six alcoholics in a test sample of six. The test sample did not contain the same subjects as the training set. Table 4 provides the results of the discriminant analysis and the F to enter tests for each measure. The discriminant function was significant ($X^2(10, N=22)=43.56$, $p<.01$). The canonical correlation squared (R^2c) for this function was .94. Examination of the F to enter ratios in Table 4 shows that all of the measures were significant. This indicates that all the measures contributed to the separation of the groups. The weights of the discriminant functions indicate that most of the

between-groups discrimination was contributed by the amplitude of the P200 and P300 components. Because P300 amplitude is the component parameter of greatest interest in studies of alcoholics, separate SWDAs were run for the rare tones, the frequent tones, and the combined rare and frequent tones. The results showed that P300 amplitude at site Cz for the rare and frequent tones correctly classified 81.82 percent of the subjects (2 alcoholics and 2 nonalcoholics were misclassified). Using only the rare P300 tone amplitudes produced a correct classification percentage of 68.18 (3 alcoholics and 4 nonalcoholics were misclassified). With only the frequent P300 amplitudes, a 63.6 percent correct classification was found (4 alcoholics and 4 nonalcoholics were misclassified).

Table 4

Standardized Discriminant Function Coefficients, Means, Standard Deviations, and F to Enter for Both Groups

Step	Measure	Discriminant Function	Alcoholics M	Alcoholics SD	Nonalcoholics M	Nonalcoholics SD	F to Enter
Amplitude of:							
1	P300, RT, Cz	-1.35	2.7	2.1	5.1	1.7	8.39*
2	P200, FT, Pz	4.06	2.7	1.2	2.2	1.5	8.98*
3	P200, RT, Cz	3.77	3.7	2.8	3.7	1.8	7.68*
4	P200, FT, Cz	-2.13	3.4	1.5	3.2	1.7	6.95*
5	P300, FT, Cz	2.65	1.5	1.2	.1	1.8	6.18*
6	P200, RT, Fz	-3.44	3.2	2.2	3.6	1.9	5.92*
9	P300, FT, Pz	-1.69	1.1	.7	.5	1.9	13.68*
Latency of:							
7	N100, RT, Cz	1.80	101.5	10.4	92.5	10.6	6.42*
8	P50, FT, Pz	-1.75	40.3	11.1	46.4	12.2	7.92*
10	N100, FT, Fz	1.17	104.6	14.0	100.2	13.5	18.98*

Note: Amplitude values are in microvolts and latency values are in milliseconds. RT = Rare Tone; FT = Frequent Tone. *p<.01

DISCUSSION

The main conclusions of this study are that the brain electrical response of alcoholics to certain stimuli may be significantly different from that of normal nonalcoholics, and the analysis of that difference via SWDA may provide an objective classification of alcoholics. It has been previously documented that the brain electrical activity of alcoholics is different from that of normals. Only one other study, however, has been found that attempted to predict alcoholic group membership by means of ERPs (Sandman et al., 1987). Sandman et al. also found that alcoholics could be distinguished from normals, bipolars, and schizophrenics by means of ERPs via SWDA. They used a different task paradigm and older subjects than did the present study (a single tone counting paradigm was used, M age=43.1 for alcoholics and 29.9 for nonalcoholics, also their alcoholic subjects were receiving disulfuram). Our subjects were thoroughly screened and found to be free of collateral pathology, and it was therefore believed that the use of contrasting pathogenic groups was unnecessary.

The finding of no performance difference between groups indicates that selective attention as measured by our task was not different between groups. The very simple task in this study may not have been sensitive enough to detect behavioral differences between the groups.

Contrary to the results of Sandman et al., the alcoholics in our study had smaller overall P50 amplitudes. A comparison with the results of the Sandman study is difficult for various reasons. One substantial factor involves the definition of P50. They state that their P50 latency window was from 30 to 80 ms, but their table of latency and amplitude values shows latencies of around 100 ms. Additionally, the authors did not find a significant P50 amplitude difference between alcoholics and normals, only between alcoholics and bipolar depressed subjects. Also, as Sandman et al. did not use a standard "oddball" counting task and did not control for age, their results are difficult to compare to the present study.

Typically, a conditioning-testing paradigm is used to elicit P50. In this paradigm, two identical clicks are presented, with an interstimulus interval of 500 ms, and the ERP amplitudes produced by the clicks are compared (Adler et al., 1982; Franks et al., 1983; Freedman, Adler, & Waldo, 1987). Although no study has been found that used a conditioning-testing paradigm with alcoholics, studies have been done with schizophrenics and have found smaller P50 amplitudes and shorter latencies in the schizophrenics (Adler et al., 1982; Franks et al., 1983). The authors concluded that "normally present inhibitory mechanisms are markedly reduced in schizophrenics." Freedman et al. (1987) used the same paradigm in a study of the effect of maturation on sensory gating and found that attenuation of P50 to the second click was not reliably observed until the age of eighteen. These studies show that differences in sensory gating, as measured by P50, may gauge inhibitory mechanisms, but do not necessarily indicate pathology. The differences observed in our study, then, may indicate that the inhibitory mechanisms of alcoholics are altered. This difference may be related to a trait of alcoholism, but needs to be further investigated with a traditional conditioning-testing paradigm.

The results of our study agree with the literature concerning ERPs and alcoholics on two significant points. We support the N1-P2 difference that has been previously documented (Porjesz & Begleiter, 1981; Porjesz et al., 1982). Our findings also support the results of studies that have found reduced P300 amplitudes (Patterson et al., 1987), and more specifically, no difference in amplitude between rare and frequent tones for alcoholics (Porjesz et al., 1982).

Windle and Blane (1989) have previously found an association between verbal ability and drinking behavior in a national sample of young adult males. They found that nondrinkers had higher verbal ability and that among those who drink, lower verbal ability was predictive of alcohol-related problem behavior. The WAIS-R verbal score differences found in our study, though significantly higher for the nonalcoholic group, were within normal limits for

both groups. Two factors may explain the higher verbal IQ for the comparison group. The first is that the comparison group had a higher mean education (M = 13.45, SD = 2.42) than the alcoholic group (M = 12.73, SD = 1.86). This difference was not statistically significant, but may have had an impact on the verbal IQ scores. Additionally, the comparison group contained five subjects who were employed as counselors. It would seem that individuals in such an occupation would be selected for and/or develop a high verbal ability. The alcoholic group was primarily composed of technicians and mechanics.

The multivariate analysis of the ERP data indicated that there were significant differences between the alcoholic and the comparison groups. Because these differences were generally consistent with the differences found in the literature, the discriminant analysis was then thought to be appropriate. It is a technique which uses linear combinations of variables to distinguish between two or more categories of cases. The variable values "discriminate" the subjects by group and therefore predict group membership (Gnanadesikan, 1989). Sandman et al. (1987) achieved a high (64 percent, 25 percent chance) percentage of classification of alcoholics by means of a SWDA procedure within an ERP study. They used four groups of subjects (controls, schizophrenics, depressives, and alcoholics), and the amplitude and latency of ERP components were used as the variables. They used an older alcoholic group (M age = 43.0) and sampled at sites C3 and C4 as opposed to the present study which used alcoholics with a mean age of 25.1. Additionally, a single tone task was used wherein the subjects were instructed to count the tone each time it occurred. This study, however, suggests that the differential diagnosis and/or classification of alcoholics is feasible. The strong discrimination between groups with the ERP in SWDA suggests that the amplitude and latency of certain components may distinguish alcoholics from nonalcoholics. The training set classification of 100 percent and the sample set classification of 100 percent indicates that the application of SWDA to the

separation of alcoholics from nonalcoholics may be of practical value. A larger training set, of at least twenty subjects, may provide for better validation of the classification equation with a larger sample set and increase the power of the analysis.

Presently, alcoholics are diagnosed by means of subjective and objective criteria. Subjective evidence is gathered by means of interviews and clinical impressions. Objective evidence is gathered from blood alcohol tests and driving infraction history. Such procedures can lead to imprecise diagnoses and can only be done retrospectively. The diagnosis of naval personnel as alcoholic, at present, often depends upon the occurrence of a significant negative incident (e. g., the member receives a driving under the influence [DUI] citation).

The U. S. Navy processes approximately 100,000 recruits each year. According to Durning and Jansen (1976), 67 percent of incoming recruits and 71 percent of the enlisted men they sampled reported either "heavy intake," "binge," or "high consequence" drinking. They concluded that the "drinking climate ... within the Navy is likely to be a function of the individuals recruited ... rather than the organizational structure and mission of the Navy per se." It would appear then that although peer pressure and stressful work environment, among other factors, may contribute to the drinking behavior of Navy men, the proneness to dysfunctional drinking behaviors is present prior to enlistment. An objective diagnostic procedure that could classify alcoholics early in their careers could result in tremendous financial savings and the avoidance of debilitating diseases (Kolb & Gunderson, 1983). Presently, three to five thousand alcoholics are treated yearly at Navy Alcohol Rehabilitation Centers. Most of these are only identified after the occurrence of a negative incident (DUI).

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATE COVERED
	DEC 1990	Interim OCT 89 - DEC 90

4. TITLE AND SUBTITLE
An Event-related Potential Evaluation of the Cognitive Performance of U.S. Navy Alcoholics

5. FUNDING NUMBERS
Program Element: 62233N
Work Unit Number:
NM33P30.005-6003

6. AUTHOR(S)
Merrill, Lex L., Kobus, David A., Rogale, Jennifer A.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Health Research Center
P. O. Box 85122
San Diego, CA 92186-5122

8. PERFORMING ORGANIZATION
Report No. 90-38

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Naval Medical Research and Development Command
National Naval Medical Center
Building 1, Tower 2
Bethesda, MD 20889-5044

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
None.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The results of the first of four sessions of a year-long longitudinal study of alcoholics are reported. The ERPs of two groups (11 alcoholics and 11 nonalcoholics) of subjects were recorded in order to evaluate their utility as objective indicators of cognitive rehabilitation. An additional analysis was done in order to evaluate their usefulness as indicators of alcoholism. The first session data supports the results of similar studies and therefore the data appears to be reliable and valid. A significant P50 amplitude difference between groups suggests that the alcoholics may have altered sensory gating abilities. The results of a stepwise discriminant analysis of the component parameter values indicated that 100 percent of the training set (all subjects in both groups) were correctly classified. The equation derived from the training set classification coefficients correctly classified six of six alcoholics in a different sample. The strong discrimination between groups suggests that certain ERP component values (P50, N1-P2 complex, and P300) may aid in the identification of alcoholics.

14. SUBJECT TERMS	15. NUMBER OF PAGES
alcohol; ERPs; human performance; cognition	25
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited